The Internal Processes
Chapter 14

- Rigid Earth to Plate Tectonics
  - Wegener's Continental Drift Theory
    - **Developed during the 1910's and 1920's**
    - Supported by the **jig-saw puzzle way South America and Africa went together**
    - **Mountain belts of Greenland, Scandinavia, British Islands and the Appalachian Mountains all match up**
    - **Dinosaur species in Africa and South America matched up**
    - **Plant Fossils matched in Africa and South America, where seeds would not be able to cross the ocean**
- Plate Tectonics
  - **Accepted by the 1950's**
    - Supported by depth soundings
    - Found seamounts/ridges or trenches
  - **Seafloor spreading**
    - **1960's new theory- by Harry Hess and Robert Dietz**
    - **Mechanism for continental drift, mid ocean ridges form from rising mantle creating ridges, spreading the ocean floor**
    - Verified by the **paleo-magnetism—reversal of pole magnetism**
    - **New crust is formed and returned to the mantle every 200 million years**
- Plate Tectonics
  - **By 1968- plate tectonics widely accepted by a scientific community**
  - **The lithosphere is a mosaic of rigid plates floating over the underlying plastic asthenosphere**
  - **Convection is driving mechanism within the Earth's mantle**
- Plate Boundaries
  - **Divergent Boundaries – where plates stretch apart**
    - **Ocean divergent boundaries**
      - Where magma from the asthenosphere pushes up through the cracks in the ocean floor – **Mid ocean ridge**
    - **Continental divergent boundaries**
      - **Continental rift valleys– East African Rift Valley**
  - **Convergent Boundaries– where plates collide destructive boundaries**
    - Most **massive and spectacular of earthly landforms**
      - **Mountains & volcanoes**
      - **Deep ocean trenches**
  - **Ocean-continental convergence**
    - **Continental crust- always overrides**

Ocean creating ocean trench

- **Earthquakes- volcanoes associated**
  - Once thought the **plate melted– new evidence**
  - **Water from ocean crust lowers the melting point causing it to melt- magma rises to develop volcanoes**

- **Ocean-Ocean convergence**
  - **Convergence between two ocean plates**
    - **Creates a volcanic island arc**
      - **Aleutian or Mariana Islands, or mature islands like Japan**
- **Continental-continental convergence**
  - **No subduction—crust is too buoyant**
    - **Huge mountain ranges**
      - Alps, Rocky Mountains, Himalayas
    - **Volcanoes are rare- but shallow**
    - **Focus earthquakes and regional metamorphism are common**
- **Transform Boundaries**
  - **Two plates slip past each other**
  - **Strike-slip fault**
    - **Conservative boundary-associated with great number of seismic activity**
      - California, great example

- **Assembly & Breakup of Pangaea**
  - **Summary of the time line**
    - **450 million years – 5 continents**- merged together to form **Pangaea**
    - **Next 200 million years; one continent**
    - **200 million years** – **Pangaea starts to break up– Laurasia/Gondwanaland**- then to even smaller pieces
    - **135 million years** -- North and South Atlantic oceans begin to open, separating South America and Africa, Mediterranean Sea began to close as Africa began to rotate northward toward Asia
    - **65 million years --**North and South Atlantic Oceans joined; South America was new Continent and moving westward, Andies growing, as So America overrode the Pacific Plate. Rockies were rising but not the Sierras
    - **"Today"** South America connected to North America
      - North America separated from Europe
      - Europe, Australia has split from Antarctica
      - India collided with Eurasia-thrusting up the Himalayas
      - All continents are still in motion except for Antarctica
      - Africa is splitting along Great Rift Valley rotating counterclockwise

        - Future of the continents
    - **<u>50 million years from now</u>**
        - Australia will straddle the equator is huge tropical island
        - Africa may pinch the Mediterranean shut
        - East Africa becomes large island like Madagascar
        - The Atlantic will widen while the Pacific will shrink
        - Southern California, now a chilly island will pass San Francisco heading for its ultimate destination in the Aleutian Trench of the Gulf of Alaska
- Pacific Ring of Fire
    - **<u>Ring of active volcanoes surrounding the Pacific Ocean</u>**
    - **Found primarily along the subduction zones of the Pacific Basin plate boundaries**
    - **Some segments along the transform and divergent plate boundaries**

- **Additions to the Basic Plate Tectonic Theory**
    - **Mantle Plumes**
        - Spots of volcanic activity caused by a thin Earth's crust allowing the magma to move to the surface
        - These are called **Mantle Plumes or Hot Spots**
        - **Hawaii and Yellowstone are known Hot Spots**
        - As the plate moves across the Hot Spot, a **hot spot trail is left, such as the Hawaiian Islands**
        - **Mantle plumes help to explain volcanic activity in the middle of plates and help to distinguish the direction of the plate's movement.**
- **Additions to the Basic Plate Tectonic Theory**
    - **<u>Accreted Terranes</u>**
        - A **<u>terrane</u>** is a **<u>small-to-medium mass of lithosphere</u>** that may have been carried a long distance by a drifting plate that eventually converges with another plate
        - **A terrane** that is **too buoyant** to be **subducted** in the collision, but is **fused and fragmented** in the **process is said to be accreted**.
        - **Terranes are distinctive geological, the rock is different from the Plate they are accreted**.
- **Vulcanism**
    - **General term that refers to all phenomena connected with the origin and movement of molten rock**
        - **Two categories– Plutonic Activities** (below the surface of the crust)
            - **<u>Volcanism – extrusive</u>**

    - **<u>Intrusive volcanism (shallow)</u>**
        - **<u>Plutonic (intrusive, very deep)</u>**

- **Volcanism**
    - **<u>Magma</u>**
        - **Molten mineral material below the surface**
        - **Lava when extruded to the surface.**
        - **Explosive material is pyroclastic material**
        - **Distribution**—Most found in the Ring of Fire or at subduction zones
    - **Magma Chemistry and style of eruptions**
        - **Felsic Magma** – Rhyolite and Granite
            - Explosive eruptions
        - **Mafic Magma** – Basalt and Gabbro
            - Slow moving, non-explosive
- **Volcanoes**
    - **Volcanic Activity**
        - Revitalizes the crust
    - **Lava Flows**
        - **Spreads outward at the altitude of the surface over which it flows**
        - **Solidifies in a horizontal orientation, with stratification**
            - Large flows from mid ocean flows are called **flood basalt**
- **<u>Kinds of Volcanoes</u>**
    - **<u>Shield</u>**
        - Broad, gentle slope,
        - Layers of lava flows
        - Basaltic magma, quiet eruptions
    - **<u>Composite</u>**
        - Large, steep, symmetrical
        - Layers of lava, proclastic
        - Magma andesitic, both explosive and quiet eruptions
    - **<u>Lave Dome</u>**
        - Small, less than 2000 ft high, irregular shape
        - Solidified thick viscous lava
        - Magma high in silica, often rhyolitic
    - **<u>Cinder Cone</u>**
        - Small Steep-sided.
        - Loose proclastic material
        - Magma varies from basaltic to proclastic
    - **<u>Calderas</u>—a crater produced from a collapsed volcano**
- Volcanic Hazards
    - **<u>Volcanic Gases</u>**

        - Emissions of noxious gases such as carbon dioxide, sulfur dioxide, hydrogen sulfide, and fluorine
    - **Lava flows**
        - Rarely cause loss of life, but cause lots of damage
    - **Eruption Column and Clouds**
        - Changes the air quality and weather
    - **Proclastic flows**
        - Collapse of the lava dome or explosive eruption causes high speed avalanche of searing hot gases, ash, and rock fragments
    - **Volcanic Mudflows (Lahars)**
        - A loose mantle of ash and proclastic flow on the sides of a volcano slides during a heavy rain storm.
- **Igneous intrusions – when the magma solidifies below the surface producing a igneous intrusion**
    - **Types of intrusions**
        - **Batholiths -- a subterranean igneous body of indefinite depth and enormous in size. Often the core of mountain ranges.**
        - **Stocks – Similar to the batholiths but much smaller. Often an offshoot of batholiths.**
        - **Laccoliths– produces by slow-flowing viscous magma is forced between horizontal laye4rs of preexisting rock.**
        - **Dikes – a vertical or nearly vertical sheet of magma thrust upward into preexisting rock**
        - **Sills– a long, thin intrusive body with its orientation determined by the structure of the preexisting rocks.**
        - **Veins – least prominent- thin veins of igneous rock that are pushed up through small fractures of preexisting rocks**.
- **Diastrophism—general term for the deformation of Earth's crust**

- **Folding**
    - **Types**
        - **Monocline** – a one-sided slope connecting two horizontal or gently inclined strata.
        - **Anticline**– simple symmetrical upfold
        - Syncline – simple downfold
        - **Overturned fold** – an upfold that has been pushed so vigorously from one side that becomes over-steepened enough to have a reversal orientation
        - **Overthrust fold** – if the pressure is enough to break the over-steepened climb, older rock rides above younger rock

- **<u>Faulting</u>**
  - **Faulting results when rock is broken under stress and displacement happens**
    - **Fault zones**—a area of weakness in the crust
    - **Fault line** – the intersection a fault zone with the Earth's surface
    - **Fault scarps**– steep cliffs that represent the edge of a vertically displaced block
  - **Types of Faults**
    - **<u>Normal</u>** –results from tension stresses (pulling apart) in the crust
    - **<u>Reverse</u>** – produced from compression, with the upthrown block rising steeply above the downthrown block
    - **<u>Thrust</u>** – complicated in structure, compression forces the upthrown block to override the downthrown block at relatively low angles.
    - **<u>Strike-slip</u>** – the movement is horizontal with the adjacent blocks being displaced laterally relative to each other.

- **Landforms Associated with Faults**
  - **Normal Faulting**
    - **Tilted fault-block mountains** – surface block may be severely faulted and upthrown on one side without any faulting on uplift on the other.
    - **Tilted fault-block mountain range** – gentle slope and a steep slope along the fault scarp. – **Sierra Nevada Mountains**
    - **Horst and Graben** – Uplift of a block of land between two parallel faults or the land between the two faults can be thrown-down
      - Example – **Death Valley or all the of the Great Basin**
    - **Rift Valleys** – Downfaulted grabens occasionally extended for long distances as linear valleys enclosed by steep fault scarps
      - Example – **Great Rift Valley in East Africa**
  - **Strike-Slip Faulting**
    - **Linear Fault Trough** – a valley formed by repeated movement and fracturing of rock within the fault zone.
    - **Sags** – small depressions where rock settled within the fault zone – may fill with water to develop "Sag Ponds"
    - **Offset stream** –a stream flowing across the fault that is displaced by periodic fault movement or diverted when a shutter ridge is faulted in front of the of the drainage channel.

- **Earthquakes**
  - **A vibration in the Earth produced by shock waves resulting from a sudden displacement along a fault.**
  - **Earthquakes may also develop from the movement of magma or sudden ground subsidence.**

    - **Fault movement allows an abrupt release of energy, usually after a long, slow accumulation of strain**
    - **Fault rupture can take place at the surface and displacement can take place at considerable depth**
- **Earthquake Waves**
    - **Focus** – or the epicenter of the earthquake. (Waves move out from the epicenter like waves in water when rock thrown in)
        - **P Waves** – move through the Earth like sound waves alternately compressing and relaxing the medium that they pass through (like a slinky)
        - **S Waves**– strong side-to-side, up and down slowing moving waves.
        - **Both P waves and S waves** are "body wave"
        - **Surface waves** arrive immediately after the S waves and produce strong side-to-side movement as well as the up-and-down "rolling" motion.
- **Earthquake Magnitude**
    - **Magnitude –the relative amount of energy released during an earthquake**
    - Calculated on a logarithmic scale
        - Each difference in scale 32 times more intense than the previous.
            - 32 times more energy is released
        - Magnitude scale developed by Charles Richter
        - Used recently "moment magnitude"
        - Used more to describe the very large earthquake
    - **Shaking intensity**– intensity scale devised by Giuseppe Mercalli in 1902
        - Updated to the **Modified Mercalli intensity scale**
- **Earthquake Hazards**
    - **Most damage from ground shaking**
    - **Liquefaction– shaking of water-saturated material.** Turns to fluid resulting in subsidence, fracturing, and horizontal sliding of the ground surface.
    - **Landslides triggered by the earthquake**
    - **Tsunamis**– seismic sea waves caused by undersea earthquakes or landslide